

Arsenic fate in the unsaturated zone upon the water table fluctuation caused by periodic irrigation practices

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Using high As groundwater as an irrigation water resource has been occurring in Asia for several decades, and the induced fluctuation of redox condition potentially affects the mobilization of As in the unsaturated zone. To identify the effects of irrigation on the hydrogeochemical behaviors of As and Fe in the unsaturated zone, a field experiment (50 m × 25 m) was conducted in the As-affected area of the Datong Basin, China. High As groundwater ($> 10 \mu\text{g/L}$) extracted from the shallow aquifer far from the field site was used as the irrigation water. The hydrochemical results monitored during the irrigation practices indicate that the vertical infiltration of irrigation water into the unsaturated zone led to fluctuations of the water table and redox conditions in the unsaturated zone, and as a consequence, the redistributions of As and Fe occur between the soil water and soil/sediment samples. After the irrigation, an increase in soil As content was observed in the topsoil, indicating the occurrence of adsorption of irrigation As onto the topsoil. Geochemical modeling results suggest adsorption/desorption, leaching, and cation exchange processes are responsible for the temporal changes of As concentrations in pore water and sediment samples during the irrigation. In addition, the introduction of organic matter, SO_4^{2-} , and NO_3^- from irrigation water further affects the (bio)geochemical cycling of As and Fe in the unsaturated zone. This study indicates that the flooding irrigation using As-rich groundwater would cause the As enrichment in the topsoil, which potentially affects the crop cultivation and leads to the As enrichment in crops via food chain. Therefore, the irrigation using high As groundwater needs to be controlled to mitigate As accumulation in the unsaturated zone.